Overview of Fractal Microstrip MIMO Antenna for Wireless Communication

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Abstract* —In the recent year's antenna communication have more popularity due to its applications. Fractal antennas may be characterized by space filling and self-similarity properties which will result in a considerable amount of size reduction and multiband operation as compared to the conventional microstrip antenna. Today design technology of fractal microstrip antenna is improved more and more and can be used for multiple inputs and multiple output system. The researchers are dragged their attention to deploy wideband antenna to enhance the features of MIMO. MIMO has various features due to these better features MIMO has grabbed the considerable attention in the wireless communication system, because of it present significant increases in data throughput and link range without requiring extra bandwidth or transmit power, higher spectral efficiency, and reduced fading. A few techniques can be applied to improve the fractal microstrip antenna, this survey paper presents an overview of the fractal microstrip antenna.

Index Terms —microstrip, fractal antenna, MIMO, wireless communication.

I. INTRODUCTION

Day to day communication systems require antennas with wider bandwidths and smaller dimensions than any other conventionally possible. The growth of communication system had changed the direction researcher to research antenna in various directions, one of which is by using fractal shaped antenna elements. So Since from many years, fractal geometries are used in applications of an antenna with various degrees of success. To improve the antenna characteristics some of the geometries have been specifically useful in reducing the size and space of the antenna. The fractals have been utilized in widespread applications in several disciplines of science and engineering. Some of the areas are geology, atmospheric sciences, forest sciences, physiology these branches have taken significant benefit by fractal modeling of naturally occurring phenomena's. The use of fractals in antenna array synthesis and fractal shaped antenna elements have been studied more and more.

In the year 1975, The term "fractal" is first used by a mathematician, well-known scientist Benoit Mandelbrot. Rumsey the scientist used an antenna with shapes only defined by angles would be frequency independent, since it would not have any characteristics size to be scaled with wavelength. Benoit Mandelbrot. Rumsey sometimes called as the father of fractal geometry; Benoit Mandelbrot. Rumsey said, "I coined fractal from the Latin adjective fractus". The word fractal word is derived from the Latin language word "fractus" thus the meaning is nothing but broken, uneven, any of various extremely irregular curves or shape that repeat themselves at any scale on which they are examined and used. Using fractal antenna maximizes increase the perimeter (the length, or on any side of the structure), of material that can receive or transmit electromagnetic radiation within a given total surface area or volume. There are different types of fractals which reveal that as you zoom in on the image at finer and finer scales, the same pattern re-appears so that it is virtually impossible to know at which level you are looking. Fractal is a concept which is being implemented in a microstrip antenna to have better characteristics. The fractals geometry is most useful, it may help in using the effective length of the fractal antennas can be increased while as keeping the total area as same.

In the view of communication, the fractal antenna had a very important role to communicate with the system, communication in remote place the antenna plays a vital role. MIMO antennas have emerged as one of the most significant technical evolution for future generation for wireless communications. MIMO is considered as one of the most important technology for improving the throughput of communication of the systems; MIMO uses the multiple antennas at both the transmitter and receiver to improve performance communication systems. A Fractal microstrip MIMO technology has turned researcher's to carry out research in wireless communications, because of its significant application those application provides significant increases in data throughput, bandwidth, and link range without requiring additional bandwidth or transmits power, higher spectral efficiency, and reduced fading. MIMO is an important part of modern wireless communication standards as specified in IEEE 802.11n Wireless fidelity, IEEE 802.16e (WiMAX), Long Term Evolution (LTE), 3GPP HSPA +, 4G and 5G systems for near to come

The role of microstrip antennas in the current wireless communication scenario plays a very important role. There are different types of microstrip antennas that are used in the design of MIMO systems. These antennas may be are narrowband elements, which limits their application in modern high data rate wireless systems. One of the major issues is mutual coupling that degrades the performance of the MIMO systems, which may arise due to the smaller spacing between the antennas.

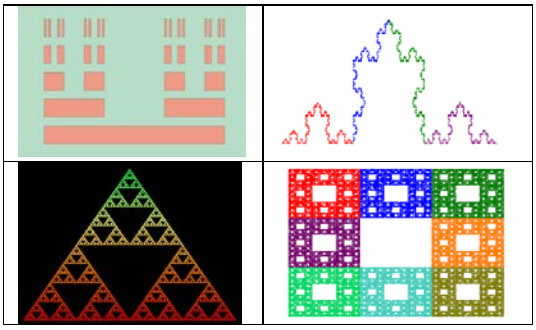


Fig. 1: Various Types of Fractals Used As Antenna a).cantor set b) Koch curve c)Sierpinski gasket d)Sierpinski carpet

II. FRACTAL ANTENNA ADVANTAGES

There are certain limitations of microstrip antenna to overcome **limitation fractal geometries applied on microstrip antenna. The fractal antenna has** several advantages as follows:

- Use of fractal geometry will help in reducing the size of the antenna not only size reduction in size the metallic portion will also decrease in this way the size of the antenna can be reduced.
- By using Fractal geometry can make the increase in resonant length, this will help the antenna to resonate at multiple bands.
- By using Fractal geometry will helps in impedance matching of an antenna.
- Fractal antenna not only helps impedance matching but it also helpful in reducing mutual coupling in fractal arrays.
- Making independent frequency for the antenna the Fractal antenna allows an antenna to operate over a large range of frequency.
- Using the fractal geometry, a bandwidth of antenna can be improved. So fractal geometry is helpful in achieving large bandwidth.

III. FRACTAL ANTENNA DISADVANTAGES

In fractal antenna there are several advantages, in spite of several advantages the fractal antenna have disadvantages like multiband characteristics, good bandwidth and gain the disadvantages of fractal geometry which are given as follow:

- Some cases area of patch decrease by a large amount due to applying fractal geometry which may lead gain of an antenna to decrease.
- For fractal antenna applying different iterations of fractal geometry, it will help in the number of bands increases but meanwhile some times complexity also increases if an increase in the number of iterations.
- Benefits of antenna begin to decrease after a few fractal iterations.
- As you increase the number of iteration, the complexity increases which may cause difficulty in fabrication.

IV. APPLICATIONS OF MICROSTRIP FRACTAL ANTENNA

Making use of fractal antenna size of antenna decreases and the number of bands also increases. The tremendous growth in wireless communications, there is a demand for the need of fractal geometry. There are many examples of a fractal antenna including handheld devices such as cell phones and mobile devices, tab, laptops on wireless LAN. Following some of the applications of fractal geometry:

- **For Radio Frequency Identification: The** Fractal antenna can be used for RFID applications. Fractal antenna plays a very important role in RFID reader and tag antenna. This types of antennas can be used for the purposes of logistics management, traffic toll collection.
- **The fractal antenna Miniature Broadband Ring like Microstrip Patch Antenna:** A miniaturizes of broadband stacked fractal microstrip patch antenna is formed by using two fractal antenna elements. One element is patch is active and the second element is patch is parasitic. Further, miniaturize can help in size reduction and achieving good gain.
- **Wideband Application:** By applying different iterations of fractal geometry antenna with wideband characteristics can be obtained. A fractal antenna is useful for super wideband and ultra-wideband applications.
- **Mobile Applications:** Mobile communication, it is necessary to use the fractal antenna as a single antenna which can be designed to resonate for WLAN, UMTS, GSM, Wi-Max, and GPS applications. Hence fractal antennas are suitable for mobile applications.
- **Integrated Multiservice in Car System:** Miniaturized antennas can be required in a car for radio reception, for cellular transmission and reception in GSM, UMTS and for a GPS navigation system. These antennas provide easy connection for most communications systems of a vehicle so the vehicle industry can use the fractal antenna.

II. RELATED WORK

The design of a small and compact with a self-affine property of multiband fractal antenna has been presented in this proposed scheme. The antenna has been designed on a substrate of dielectric constant €r = 4.4 and thickness 1.6mm. The compact overall dimension of the proposed antenna is characterized. It is probe fed fractal patch of iteration two. It is being observed that the antenna is radiating at multiple resonant frequencies. The resonant frequency is shifted from 2.32 GHz to 1.75 & 1.26 GHz after I & II iteration respectively. So the considerable size reduction of 48% & a total bandwidth of 8.6% patch on one side of the dielectric substrate (€r≤10), with a ground plane on the other side. The proposed method of an antenna is simulated using the method of moment-based commercial software (IE3D)[1].

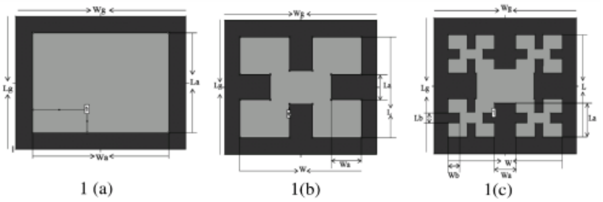


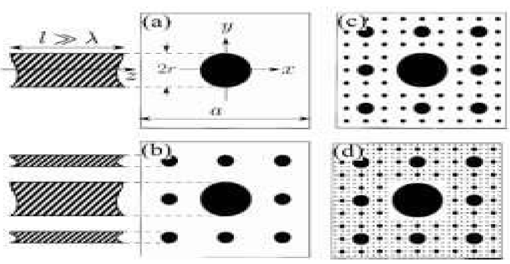
Figure: 2.1(a) Geometry of Fractal Reference Antenna,1(b) First Iteration Fractal Antenna,1 (c) Second Iteration Fractal Antenna

Design Multiband antenna based on fractal concepts. Fractal antennas show multiband behavior due to self-similarity in their structure. The design of the plus-shaped fractal antenna used on a substrate of dielectric constant €r = 4.4 and thickness 1.6 mm. The antenna is characterized by compact size and it is microstrip feed fractal patch of order 1/3. It is observed that the antenna is radiating at multiple resonant frequencies. The resonant frequency is reduced from 2.2 GHz to 900 MHz after I & II iterations respectively. Thus a considerable size reduction of 81.77% & overall bandwidth of 12.92% is achieved. The proposed antenna is simulated using the method of moment-based commercial software (IE3D)[2]

The design and study of 2.4 GHz (ISM band) rhombus shaped Microstrip antenna along with fractal geometry is made. A fractal antenna shows multiband behavior due to self –similarity in their geometrical structure. The proposed fractal antenna resonates at 1.72 GHz with zeroth iteration and resonates at 1.37 GHz with the first iteration respectively. Thus the size reduction of 68.96 % with an overall bandwidth of 380MHz is obtained. Simulation is carried out using IE3D software[3].

F Multiband behavior for Sierpinski Monopole new self-similar fractal antenna based on nearly square shape with circular polarisation. This new antenna which is called Cmwn SquareFractal antenna displays lower tint made frequency than a normal nearly square micro By applying the Crown Squam microstrip antenna, the size is reduced compared 10 a nearly square antenna 81 the first resonant frequency. At higher moment frequencies Crown Square antenna has a larger VSWR bandwidth with two circularly pledged bands through which the radiation [4].

SamanehMoeini et al. [5] proposed Fractal Metamaterial is based on Sierpinski Carpet. The author is had to implement the idea of fractal geometry in a metamaterial structure, the two-dimensional metamaterial will be formed by an array of parallel metallic cylinders, the wire medium [WM]. This metamaterial had a stop-band at frequencies below an effective plasma frequency which is determined by the radius of the cylinders and the structural period. The study of a wire medium type metamaterial with the wires distributed in accordance with the Sierpinski carpet fractal and also had simulated the band diagram of that fractal structure for TE and TM polarized waves. Those results have shown that the Sierpinski wire medium structure in certain cases outperforms traditional periodic wire media.



V. Dinesh et al. [6] proposed the analysis of Microstrip rectangular carpet shaped fractal antenna for single and multiband applications. Design and simulation had done using HFSS 13.0 software and fabrication had done using a photolithography etching method which gives the adequate result for that type of antennas. The designed antennas were used in implantable medical [IMD] applications and other wireless applications. In that paper, rectangular carpet fractal antennas had been designed and tested. The results obtained are in agreement with the desired results. The Rectangular Carpet Fractal Antenna resonates at two frequencies, i.e 3.6 GHz and 7.0 GHz and percentage bandwidths are 9% and 6% respectively. Our result indicated that the bandwidths around the two operating frequencies are sufficient for the dual-band wireless operations.

Ravi Panwar et al. [7] described fractal frequency-selective surface embedded thin broadband microwave absorber coatings using heterogeneous composites that operates for a wide range of frequencies. That work had to present the technique of blending a fractal frequency selective surface [FSS] with single- and double-layer coatings. These coatings are comprised of well-optimized micrometer-sized [80–90 m] and nano-sized [20–30 nm]Ti particles based Fe3O4 [80–100 nm]composites.

The main objective of that study had to achieve good absorption with wide bandwidth. The double-layer coating with a higher order Sierpinski gasket fractal FSS shows remarkable absorption characteristics as compared to a double-layer coating without a fractal FSS. The measured RL of 36.38 dB at 11.3 GHz and corresponding bandwidth of 3.1 GHz is achieved for double-layer coatings without FSS.

On the other hand, the Sierpinski gasket fractal FSS embedded double-layer composite coating with a thickness of 1.4 mm possess an RL of 35.57 dB at 9.5 GHz with a broad bandwidth of 4.2 GHz. Therefore, combining a Sierpinski gasket fractal FSS with double-layer heterogeneous composite coatings had proved to be a good concept that can be used for various practical applications.

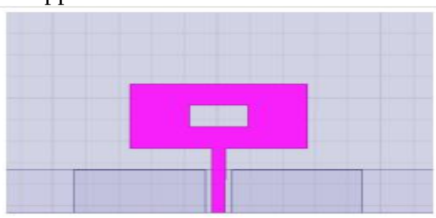


Fig. 2: 1st iteration of carpet fractal Antenna

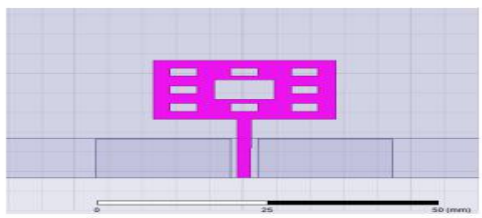
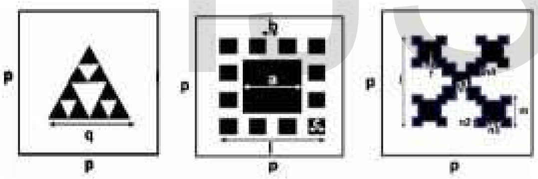


Figure 2: Iteration level of Sierpinski gasket fractal

Pratik Lande et al.[8] experimented the Design and Development of Printed Sierpinski Carpet, Sierpinski Gasket and Koch Snowflake Fractal Antennas for GSM and WLAN Applications. In that paper, three configurations had to be used of printed fractal antennas, such as Sierpinski Carpet, Modified Sierpinski Gasket, and Koch Snowflake are designed and developed for multiband operations for GSM 1800, WLAN 2400/5800 applications. The desired resonant frequencies had been tuned for VSWR 1:2. The comparison between results for the three antennas indicated that the peak directivity and peak gain increases for increasing frequency. The radiation efficiency of all the three implemented antennas for that desired frequency is in the range was 0.8 to 0.92.

MaíraGonçalves Santos et al.[9] had designed the Microstrip wideband antennas with different fractals geometries for wireless applications. That paper had to present three microstrip antennas models using different fractal geometries. The radiators had to be developed by applying Cantor's comb, Sierpinski carpet and Sierpinski triangle combined with the feed systems that enable large bandwidths operation. One of those structures was developed with Cantor multifractals in 38.5mm×76mm×0.9mm dimensions and acceptable performance from 3GHz to the 20GHz frequency range. The Sierpinski carpet model operates between 2.1GHz and 20GHz, and its dimensions are 164mm×166mm×1.6mm. Finally,



designed with Sierpinski triangles had 94mm×94mm×1.6mm dimensions and presented a bandwidth between 6.2GHz and 20GHz, by using the same parameters evaluation. Those structures show good performance concerning the power gain, impedance matching, and analysis of their radiation diagrams in a large bandwidth.

S. C. Patrício et al[10] experimented the Development of a Printed Antenna Array based on Sierpinski Carpet Fractal Elements. Its main goal had to increase the array directivity by means of ensuring the radiation beam. We had been reported the development of a printed antenna array based on three Sierpinski carpet fractal elements and a reflector plane. It had been numerically and experimentally analyzed in terms of the reflection coefficient and radiation pattern properties. The proposed approach enabled to enhance the gain at 5.8GHz in 5.2dB, i.e. from 4.5 to 9.7dB. By proper manipulating the current phase and amplitude of the array elements, its radiation pattern becomes reconfigurable. The proposed printed antenna array applicability had been successfully illustrated by performing an experimental performance analysis of a point-to-point wireless link with QPSK and 16-QAM modulation formats. That array had been applied to modern wireless technologies that require the broadband operation and high gain.

M. Karthick et al. [11] had proposed the Design of IRNSS Receiver antenna for Smart City Applications in India. In that research paper, a rectangular fractal antenna had been used for IRNSS based smart city applications in India. For tracking and positioning applications, the government of India had

VI. CONCLUSION

This paper is a survey on the technological advancements in fractal microstrip antenna over many years. The small size, wideband and multiband antennas are most widely required in the communication system using fractal geometry, the size of the antenna reduces The metallic portion is reduced due to the use of various fractal geometries, improvement in the input impedance matching, using fractal geometry we can achieve a consistent performance over a large range of frequency. .Cellular phones, airplanes, space crafts, and missiles. A huge amount of research work is going on fractal microstrip antenna for the better utilization in the next generation wireless communication. MIMO is considered as one of the important techniques for improving the throughput, bandwidth, bit rate, error rate of future wireless broadband data systems. Survey has given an brief idea to enhance the features of fractal microstrip antenna and enhancing the bandwidth using techniques such as introducing parasitic element either in coplanar or it may be in stack configuration, increasing the substrate thickness and modifying the shape of a patch and inserting slots to explore new possibilities of new wideband fractal microstrip antenna. A number of advancements have occurred and are being used today. However, the communication system increasing the demand day by day there are a lot of issues and challenges which are facing even today. A fractal antenna is the most critical element of the wireless communication system.

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